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MORIN TRANSITION IN α-Fe_2O_3 NANO-PARTICLES INDUCED BY INTER-PARTICLE INTERACTIONS

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In bulk α-Fe_2O_3 (hematite), the Morin transition takes place as a first order transition at $T_M \cong 263$ K. At T_M, the spin structure changes from being confined to lie in the rhombohedral (1 1 1) plane above T_M to lying along the [1 1 1] axis below T_M. With decreasing particle size, T_M decreases, and it has been reported that there is no Morin transition above 4 K in α-Fe_2O_3 particles smaller than ~ 20 nm in diameter. However, we have found that 9 nm α-Fe_2O_3 particles interacting with NiO nanoparticles show a gradual Morin transition at low temperatures.[1, 2] The Morin transition was neither observed in pure samples of the 9 nm α-Fe_2O_3 particles, nor when the α-Fe_2O_3 nanoparticles were exposed to Ni^{2+} or mixed with CoO particles.[2] Here, we present a combined Mössbauer and neutron diffraction study of α-Fe_2O_3 nanoparticles interacting with NiO nanoparticles. In Mössbauer spectra the Morin transition is clearly visible because the quadrupole shift, ε, changes from $\varepsilon = -\ 0.1$ mms^{-1} above T_M to $\varepsilon = +\ 0.2$ mms^{-1} below T_M. The spectrum of α-Fe_2O_3 nanoparticles mixed with NiO showed $\varepsilon \approx +\ 0.2$ mms^{-1} at 20 K. With increasing temperature, up to ~ 160 K, there was a gradual change of the spectra, indicating a Morin transition. Over a range of temperatures ε was about 0 mms^{-1}, approaching – 0.1 mms^{-1} around 160 K. The observations suggest that the sublattice magnetisation in a temperature range is neither fixed in the [1 1 1] direction nor in the (1 1 1) plane. At the highest temperatures, the analysis of the Mössbauer spectra is impeded by superparamagnetic relaxation. In neutron powder diffraction measurements, the data are not influenced by superparamagnetic relaxation and the gradual transitions can be followed by measuring the relative intensities and shapes of the magnetic [1 1 1] and [1 0 0] reflections.

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